THE RAIYĀN MOERIS.

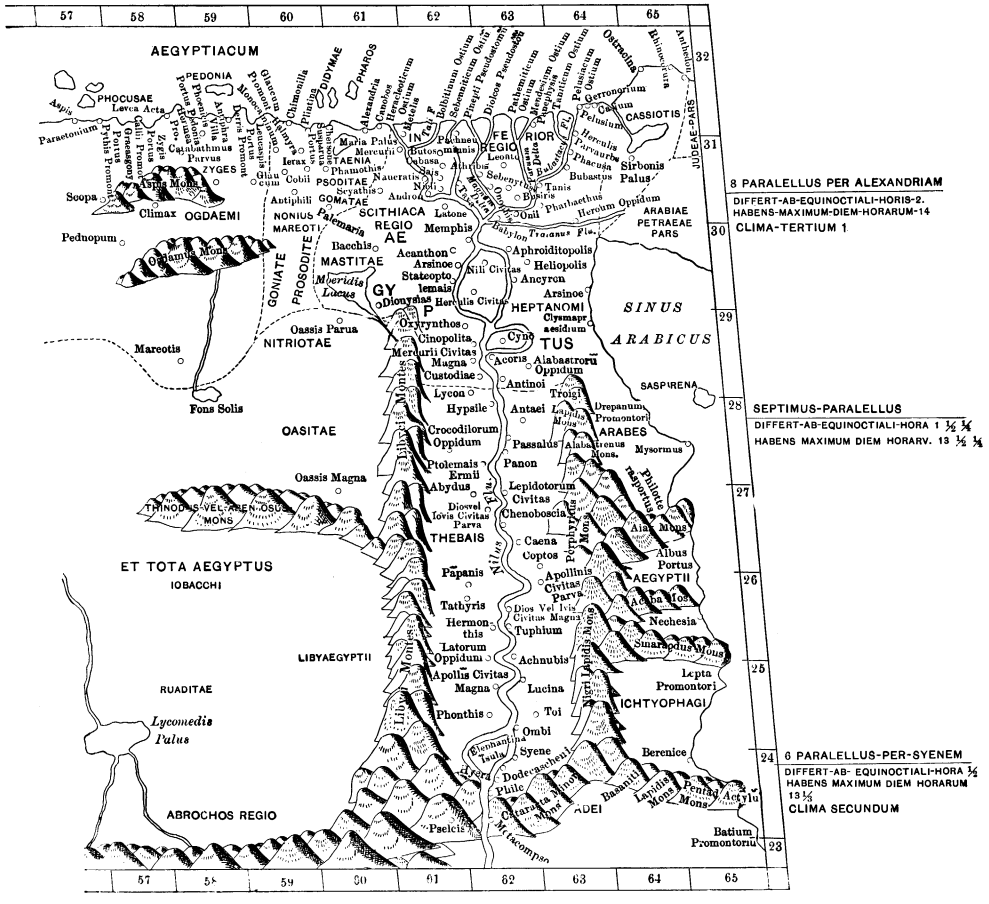
BY

COPE WHITEHOUSE.

The Journal of this Society (Vol. XIV.) contains, under the title of Lake Moeris, the results of those early explorations in the Fayoum and the adjacent desert which have now assumed a transcendent importance. The claim there made for the great inland sea has been fully justified. The vindication of the integrity and intelligence of the ancient historians is complete. The splendid engineering works of remote antiquity dazzle the eye and stimulate the imagination of statesmen and engineers, who study the arid plains of the Western States or watch the turbulent floods of the Father of Waters.

Diodorus, the Sicilian geographer, thus describes what he saw during his visit to that part of Egypt: "A little south of Memphis a canal was cut for a lake, brought down in length from the city forty miles. Its usefulness was worthy of all admiration and the magnitude of the work incredible. The circuit of the lake is said to be four hundred and fifty miles; and, in many places it is three hundred feet in depth. Who is he, therefore," he exclaims, "that considers the greatness of

NOTE.—This paper contains the substance of an address made before this Society on Nov. 11, 1889. It was illustrated by lantern slides which gave the complete cartography of Middle Egypt, including hieroglyphic, Greek, Arabic and modern maps; as well as by original views of the Bahr Jūsuf, the Fayoum, Raiyān and Muellah depressions, and the adjacent desert.



ANCIENT EGYPT.

Drawn from the map in the Ptolemy of 1508.

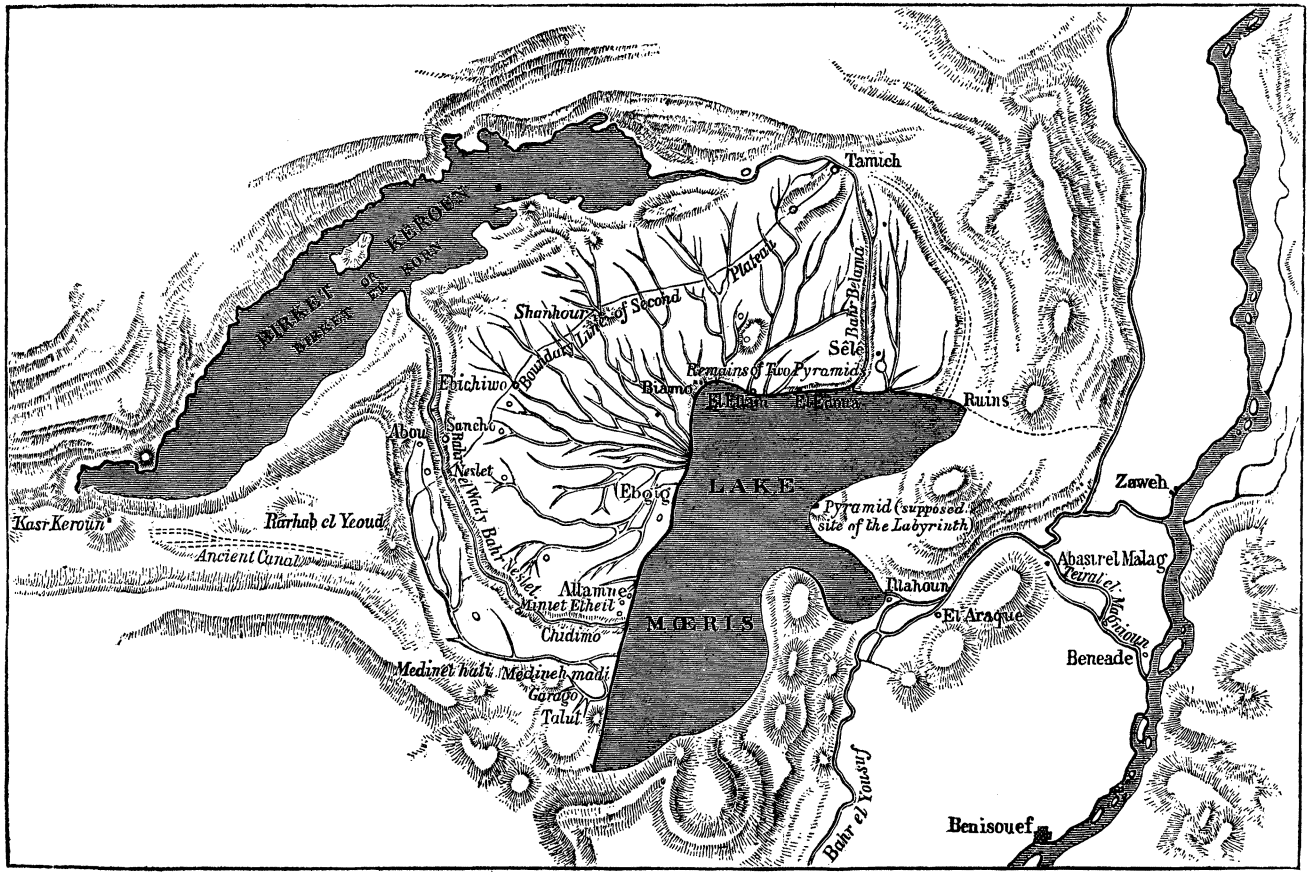
this undertaking and does not feel impelled to ask : ' How many thousands of workmen were employed, and how many years were spent in completing it?' Yet, considering the benefit and advantage brought to Egypt by this great work, none ever could sufficiently extol it according to what the truth of the thing deserves. For inasmuch as the Nile never kept to a certain and constant height in its inundation, and the fruitfulness of the country depended upon its uniform and regular supply, this lake was formed to receive such water as was superfluous, that it might neither immoderately overflow the land, and so cause marshes and stagnant ponds, nor, by flowing too little, prejudice the crops for lack of water. Accordingly the king dug a canal from the Nile to the basin, ten miles in length, and three hundred feet in breadth. Into this the water was allowed to run at stated times, and at other times it was diverted and turned over the cultivated land for seasonable periods, by means of sluices which were opened or closed, not without great labor and cost. This lake continues to the benefit of the Egyptians for these purposes to our own time, and is called the Lake of Myris or Meris to this day."

The chief facts given by Diodorus had been anticipated by Herodotus and were confirmed by Strabo and Pliny. It was thus that the attack upon the credibility of Herodotus in reality involved the whole ancient world. Readers and purchasers of books must be held responsible for the demand which creates the supply. Cæsar and Cicero, as well as Plato and Aristotle, would share in the condemnation, although actual mention of Moeris found no place in their works.

The plain account had been flatly contradicted. It was supposed that the observer "embraced in his measurement the whole water system of the Fayoum," or had "confused units of measure," or "the direction of the canal with that of the lake." The accounts of Herodotus (B. C. 454), Diodorus (B. C. 20), Strabo (B. C. 24), Pliny (A. D. 50–70), were declared to be "widely different" and "irreconcilable." Finally the scientific world came to the unanimous conclusion that Moeris was "an artificial reservoir, forty-five miles round, twenty-five feet deep at high Nile and drained at low Nile when the waters had been used upon the fields of the Fayoum. It was everywhere stated that the position of the lake had been satisfactorily determined, in this sense, by M. Linant de Bellefonds. The map reproduced from the "Egypt" of Canon Rawlinson (1881) shows the accepted view.

The French Government had also printed upon its map (1882) that the Memoir of M. Linant contained all the information which could be desired. The name of Rawlinson, identified with wide-spread geographical knowledge, a thorough acquaintance with Herodotus and the current researches recorded by the Royal Geographical Society, is sufficient to show that no suspicion of error on Linant's part was then entertained.

It is not necessary or expedient to trace here the successive steps which have resulted in our possession of an immense body of accurate observations made by a series of experts. Cartography, geology, history and archæology are represented by men of high rank, while from the Premier of Egypt to the Prime Minister of Great Britain, documents have been issued showing



MAP OF THE FAYOUM, SHOWING THE BIRKET-EL-KEROUN AND THE ARTIFICIAL 'LAKE MŒRIS.'

According to Linant de Bellefonds.

From Rawlinson's Egypt, 1881.

that the suggestions, embodied sometimes in little more than a pregnant phrase, are deemed to have a bearing upon the welfare of Egypt, the future of Africa, and the imperial interests of more than one Great Power. "Beside Lake Moeris," said Herodotus, "lies the Labyrinth. I visited this place and found it to surpass description." Beside the Fayoum and Raiyān basins in their physical conditions as developed by the engineer lies an edifice which has some of the romantic elements of the palace of Aladdin. The lamp which traces its walls reflects a thousand figures weird, and yet with many a familiar feature. In its twelve halls are throned twelve patriarchs. The history of one, at least, who dwelt on the banks of the Nile, is a household tale on the slopes of the Himalayas, and the prairies of the West. Into these sinuous passages and recondite researches we may not now enter. The Rabbi Benjamin of Tudela points to this "land of the West" (Pi-Tum), and says: "Here is Pithom. Here are the remains of the buildings erected by our forefathers." Jablonski could write, but dared not publish, that the Fayoum was the land of Goshen, vainly sought by the modern scholar in the pestilential marshes of Menzaleh, or the scant strip traversed by the Ismailia canal. The only questions we are authorized to discuss are those purely geographical points, which were outlined by the President of this Society in the remarks in which he summarized the issues raised in the former paper on Lake Moeris. He assumed that the geographical features set forth with such detail and minuteness were accurate and trustworthy. Further evidence on this point will be duly marshalled and original authorities cited. An examination had been

made of all the cartographical evidence from the time of Claudius Ptolemy. The fac-simile of the map of Egypt from the edition printed in Rome in 1508, and similar to several of those manuscripts which abound in the Vatican and other European libraries, can now be compared with an official map, stamped with the approval of the International Jury at the Paris Exposition.

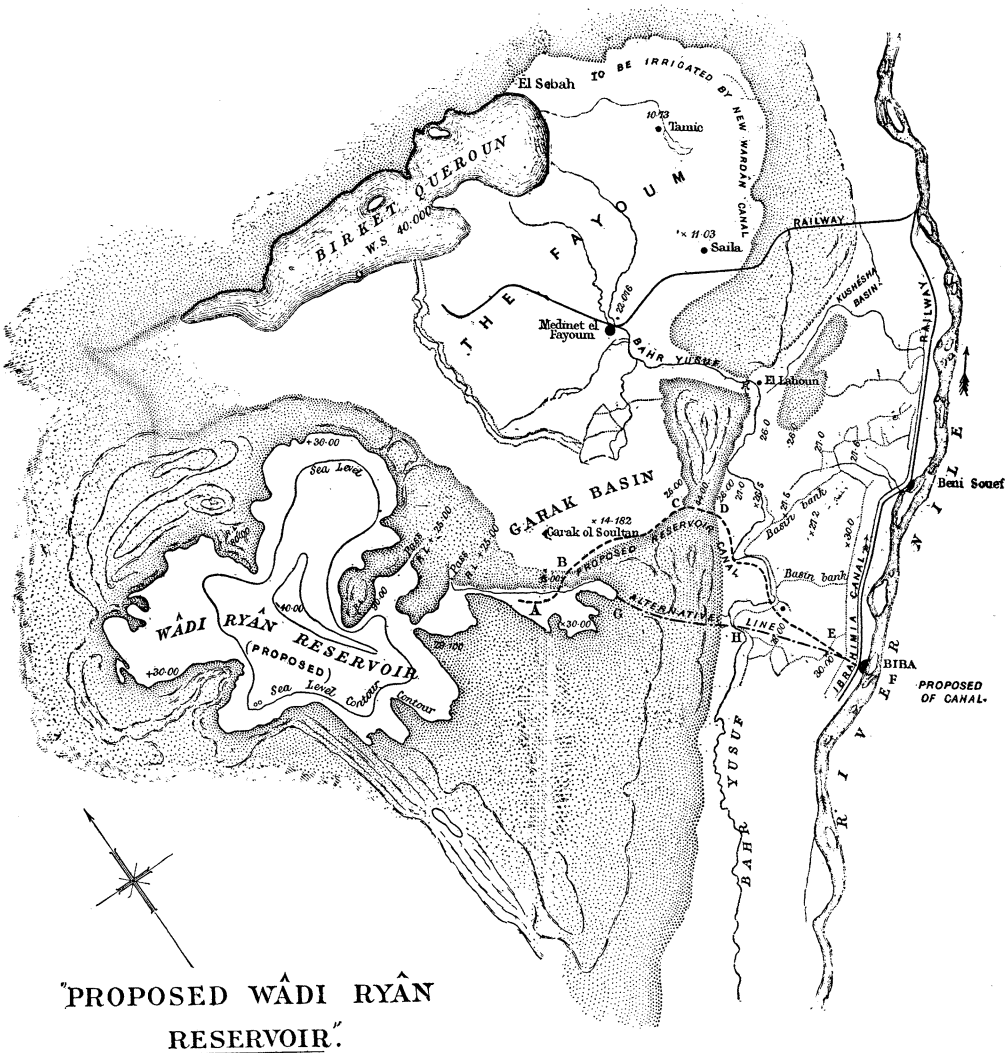
The undoubted existence of comprehensive and stupendous works, still used for their original purpose after the lapse of 4,000 years, shows what estimate should be formed of the capacity of the rulers of Egypt to design and its inhabitants to accomplish. It has an important bearing upon current philosophy and the strangely rash and incoherent assertions of rate of progress and development.

The wish of your President has been fulfilled. The condition of things in Egypt has brought about a survey of this neglected region, not merely with a view to gratify curiosity in respect of its past condition, but to point out the means of guarding against calamitous results from the action of the Nile. These investigations are apparently on the eve of being turned to practical account, and a part of the surplus of the inundation diverted into the Wadi Raiyān. The lesson has already been taken to heart in the New World. The Mississippi and the Rio Grande will yet be treated as the Nile. The engineers, who trace back their technical education in geometry to the engineering schools in the University of Memphis, are scanning with interest the tradition that makes the Patriarch Joseph the founder of their profession, and studying with profit the mighty works that were done of old and still endure.

Curiosity has, unfortunately, also been directed to the archæological treasures of this region. Savage attacks have been made upon its monuments, and thousands of tombs rifled with hideous disregard of decency. It tempts one to deplore that so much had to be said, and to guard with jealousy the secrets still undisclosed. It is for the members of this Society to use their moral influence to secure to Egypt the undisturbed possession of the treasures accumulated in the past, as well as to aid its industrious peasants to obtain such further benefits from the Nile as will put the government once more in a position to devote its surplus earnings to the advancement of art and science within its borders, and extend humanizing influences through Central Africa.

The accompanying map—reduced from the large map 1:50,000—prepared in the Department of Public Works in Cairo, succeeds and replaces several smaller maps, resulting from the surveys made by me, or by engineers put at my disposal by the Egyptian authorities.

Colonel Ardagh, C.B., R.E., then chief of staff to the British army of occupation, but now holding the high and responsible position of Secretary to the Viceroy of India, was the first English officer to visit the Wadi Raiyān. At the meeting of the British Association in 1887, before the London Chamber of Commerce in 1888, and in the Proceedings of the Royal Geographical Society in 1889, he has enforced the importance of the Raiyān depression. It was largely due to his support that the Irrigation Department consented to further an official examination of this area. The scientific world owes him this addition to the large debt which it acknowl-



"PROPOSED WÂDI RYÂN RESERVOIR".

From Egyptian Irrigation, by W. Willcocks, 1889.

edges for his topographical labors elsewhere, and his map of the neighborhood of Tel el-Kebir.

Captain Surtees, for several years on the staff of the Egyptian army, whose military services had been fully appreciated, after his return from the mission to Central Arabia, on which I accompanied him, was detailed in 1887 to examine the Fayoum in the strategic aspect, which had been outlined to General Sir Evelyn Wood, and to join me in an expedition to settle the western limits of the two depressions. The results are recorded in official documents in the Foreign Office, and in the Proceedings and on the map of the Royal Geographical Society for that year.

The Paris Geographical Society had early recognized the probable value of these investigations. In 1886 it preferred a request for an address, which, in compliance with their wish, was made without notes, but a summary was published in their Bulletin.

The *Exposition Universelle* offered an opportunity of exhibiting a number of maps, surveys and official documents. These satisfied the experts, who represented the various countries of the world, that the generous confidence so liberally extended to a stranger had materially helped to protect and mature the ideas which had, in fact, first found shelter in the pages of the *Revue Archéologique*. This collection of maps included a portion of a hieroglyphic map, whose central part is preserved at Būlaq. The remainder was found in a country house near Lincoln, England, and the fact announced in a volume offered by Egyptologists to Dr. Leemans. At the Congress of Orientalists in Vienna, Dr. Pleyte of Leyden, who was the first to embody the Raiyān basin

in any map published on the Continent of Europe, brought to my notice a papyrus in the possession of Dr. Reinisch. It was readily identified as the fragment stolen from the museum at Būlaq, of extreme interest in cartography, and whose probable destruction had long been lamented.

Various reports on the Raiyān Basin by Sir C. C. Scott-Moncrieff have less value than would have been anticipated from the world-wide reputation of the author of "Irrigation in Southern Europe." It naturally seemed to him scarcely within the bounds of ordinary human events, that, in a brief interview, one whom he had never seen before, who was to leave Egypt the next morning, should draw a few lines on a scrap of paper, add and subtract a few figures, and offer to the future Under-Secretary of State for Public Works, without any condition or apparent expectation of reward, an unrivalled occasion for enhancing personal reputation, saving a distressed people, and reconciling in one great enterprise the conflicting interests of France and Great Britain. Whether those lines were worth hundreds of millions of dollars is still a matter of calculation. The estimates made by Sir C. C. Scott-Moncrieff, which at Sir Evelyn Baring's suggestion he published in the *Journal Officiel*, a year since, were—confessedly—intended to minimize the dissatisfaction expressed at the delay in the actual execution of the project. They showed a net profit of ten per cent. on the estimated cost, but must be considered as the work of the statesman, not of the engineer. He treated the death-rate of Cairo—92.7 per 1,000 in July—as a *quantité negligeable*, and the obligation to furnish water to the Suez Canal Company, as well as to

the peasants of the Gizeh Province, for which they have long been annually taxed, as the payment of a debt, and therefore not a source of additional revenue. The quittance of these and similar obligations was excluded in the estimate of profit to be obtained from the execution of the scheme.

Lieut.-Col. Western, C.M.G., R.E., Director-General of Works, was charged in 1887 with an examination of the whole project. His great ability and thorough knowledge of construction have been proved, notably at the Barrage, but also in many minor works. If his estimates of cost seemed large, and even the enormous area of three millions of acres, to be added to Egypt by the creation of the Raiyān Reservoir, capable of increase, his invaluable reports are not to be criticised. His personal examination of the region with further facts have combined to modify, to some extent, his conclusions in a more favorable sense. These reports constitute the basis on which everything has since proceeded. They were the complete official acquittal of those who had preferred the statements of Herodotus and the maps of Cl. Ptolemy to those of Dr. Lepsius and the modern cartographers.

Lieut.-Col. Ross, as Inspector-General of Irrigation, has, like Sir C. C. Scott-Moncrieff, been in a measure hampered by his official position in the expresion of opinion. His map of the Fayoum and Raiyān depressions is constantly receiving new items of great interest, especially in that northern part where a large area of cultivable land was found by me, and brought to the notice of the British and Egyptian Governments at a time when the refugees from the Sudan were demanding aid to establish new homes. To Colonel Ross

was due the diagram of the rise and fall of the Nile for fourteen years, which was a prominent feature in the exhibit in Paris; as well as countless suggestions and continuous moral support.

The relief-map of the Raiyān Basin—horizontal scale 1 : 100,000; vertical scale 1 : 10,000—made by M. Muret under my supervision, aided by photographs, was so striking in its contrasts, that it completely broke up, in the minds of all who studied it, the fatal error, so universally entertained, that the desert traversed by the Nile is a sandy plain. The difference of scales is unusually great, and therefore far less deceptive than those maps in flat relief, which seem to the inexperienced eye to give a natural appearance to the mountains and valleys.

There was also submitted for the examination of geographical experts a large map of the North-eastern Delta with the areas actually productive or capable of being rendered cultivable by an additional supply of water free from alluvial deposit. This map was due to Mr. Garstin, who, as Inspector of Irrigation for the Eastern Delta, is well acquainted with the region.

Major Brown, R. E., is in charge of the provinces of Middle Egypt, traversed by the Bahr Jūsuf or River of Joseph. Why should oriental scholars have overlooked those written traditions, which, dating back from the 9th century to the period when the Book of Genesis first embraced the 49th chapter, have always assigned this work to the Hebrew Premier, whose sagacity founded the temporal fortunes of his race? The claim put forward in behalf of Saladin—chivalrous opponent of Cœur de Lion—comes nearly two cen-

turies after Masudi, in A. D. 956, had described the island and habitation of Joseph, the province of *Ben Jusuf*, as it is suggestively termed on Mercator's map, and the Beni-Suef of our own day. Several beautiful photographs, taken by Major Brown with artistic taste and technical skill, illustrated the lecture delivered before this Society and the expeditions we made, in which we followed this great stream. Like the reputed author of its existence, it bears a name to show, that, separated from the parent Nile, it takes away the reproach of barrenness from a large district and adds yet another province to the area assigned by Semitic tradition, ancient and local, to the shepherd kings and their allies —the Beni-Israel.

Mr. Marshall Hewat is Inspector and Director of works in the Fayoum. The photographs showing the palace of the Mūdir were proofs of the hospitality so often enjoyed, and of the information obtained directly from him as well as from the governors—my old friend Murad Pasha, and the present Governor, an accomplished and learned professor, Latif Bey Salem.

Nubar Pasha had at various times urged upon His Highness, the Khedive, and his immediate associates in the government of Egypt, the necessity of providing an additional supply of "*sefi*," or "low Nile" water, himself prepared with a project for a great dam at Silsileh. The danger of creating a storage reservoir by a dam across a large stream is well known. The engineer seeks, by preference, to use some supplemental stream, issuing from a lateral valley.

The Silsileh project has of late been associated with the name of Mr. de la Motte. It was, however, so ob-

vious a means of accomplishing a desired object that it had been mooted since the expedition of Bonaparte, and its advantages and serious dangers carefully weighed by successive ministers, especially by Ali Pasha Mubarekh, when Minister of Public Works. The Khedive opposed it, with characteristic soundness of judgment. He has recently been termed by the late Consul-General of the United States a model prince. His sons will soon visit the United States, and this Society will, without doubt, take that occasion to express their appreciation of this ruler of Egypt, who is the devoted husband of one wife, an affectionate father, profoundly religious, wisely administering his private affairs, and discharging his duties as Viceroy, under circumstances of extreme difficulty, with a tact and zeal which have won the respect of all who know him, and the loyalty of his people.

In the *Zeitschrift der Gesellschaft für Erdkunde* (Berlin, 1886, No. 2), Dr. Schweinfurth has given an account of his expeditions through the Muellah, Raiyān and Fayoum depressions, with a map. It is in the form of a letter to Dr. Ascherson, and contains much valuable geological information. It will be remembered that it was stated in the Journal of this Society, that I had received information of the existence of a temple in the desert to the north of the Birket el-Qerūn. Its position was indicated to the north of the ruins described by Dr. Lepsius, at Dimeh. The engineer, however, whom I had taken with me to Dimeh, insisted upon my agreement to return him to Medinet before a given date. Dr. Schweinfurth found the building without difficulty, and enjoys the credit of having been the first

European to visit and describe it. Accompanied by Lieut.-Commander Ackley, U. S. N., I visited and photographed it in March, 1889. It is a rectangular building, about 70 feet in length, 25 in depth, and 18 in height. The photographs were examined by MM. Chipiez, Maspero and Naville. They consider the structure, in all probability, of extreme antiquity, *ca.* B. C. 2,000. Its geographical importance is very great. Situated five miles from the shore of the present lake, at the level of high Nile at el-Lahun, and at the foot of the steep terraces which bound the depression to the west, it must have been constructed when the Fayoum was a vast lake. It would then have been a point of military importance on the desert road from the south to the Natron lakes or (the ancient) Alexandria.

Dimeh is also detached; so that it would appear as an island rising with steep sides out of the lake, where it was deepest. If Diodorus states that he saw such an island, crowned with two pyramids, against which were colossal seated figures, and a tomb, where the water was 300 feet in depth; and, if in the Fayoum there is a detached hill, with a long horizontal street or quay, covered with immense masses of unburned brick and stone, which, when the Fayoum served as a back-water and flood-escape for the Nile, may have corresponded to this description, is it creditable to insist any longer that the statements of the Sicilian geographer and traveller are false? Herodotus before, and Pliny afterwards, refer to the same remarkable feature. The pyramids of el-Lahun and Hawara, at either end of the Fayoum canal, are of unburned brick. The island-pyramids may have been of the same material. In any event the

stones at Biahmu ought never again to appear in any argument as in any way identified with these pyramids, or with the statues as *in situ*. It is an elementary rule of evidence, which is constantly ignored by untrained minds, that you cannot discredit your own witness. The only knowledge of these structures is derived from the written statements of Herodotus, Diodorus and Pliny. The whole story may be rejected, but it is puerile to admit their existence and then to identify pyramids and statues with extant remains on the upper terrace of the cultivated land, when the only important fact was the indication which the island furnished of the great depth of the "excavated" or "eroded" depression.

The contours of the Fayoum have not yet been completed. It was urgently impressed upon Sir C. C. Scott-Moncrieff, in 1886, that lines should be run which would determine the entire area of the alluvial deposit of the Nile, from Assuan to the Mediterranean. It might have been done without appreciable cost to the Egyptian Government had my offers been accepted. Unless, however, an engineer had been lent to me who would be responsible to the Government for any error, neglect or disobedience of orders, the Public Works Department would not have accepted the work as final. Some such survey will, it is believed, be undertaken at no distant date.

The contour of high Nile, quitting the Nile Valley at el-Lahun, passes to the south of Gharaq, enters the Wadi Raiyān, encircles the Wadis Lulu and Safir, re-enters the Wadi Raiyān, crosses the entrances of the Oases of Muellah and Khoreif, and returns into the Fayoum after girdling an area of 250 square miles. This same contour, of R.L. + 30, would continue

round the west of Gharaq towards the north and east, and then passing westward to the south of Qasr Qerūn, turn to the north, and, sweeping out into the desert behind Dimeh to the ancient temple, curve towards the east, and return to the south and the Valley of the Nile along the foot of the hills which overlook the ancient bed of the Bahr Wardan.

It may be said that this line when it had reached el-Lahun and the cultivated land in the province of Beni-Suef, would, especially if the minor sinuosities were measured, attain a length of 450 miles. The entire basin, thus encircled, would apparently cover over 1,300 square miles, and a large part of it would be much below the level of the Mediterranean.

This was the immense natural back-water of the Nile, which, according to Semitic tradition, was divided between the fertile province to the north, when el-Hūn or Phiom (the Sea) became el-Fayoum (Alf-iom, the land of a thousand days), and the Raiyān Moeris, or reservoir to the south.

If the Arab tradition is correct, King Raiyān invested Joseph with the insignia of Prime-Minister as a reward for about 400,000 acres of land, perennially irrigated. Manetho says that this region was abandoned in the religious wars which broke out at the time elsewhere fixed as the birth of Moses. The Birket el-Qerūn rose, if not then, subsequently. The Lake of the Horns submerged once more the district of Qerūn (Heroon-polis) to the upper plateau, where repeated use of the word Sen points to Ha-Sen (Gesen, Goshen), Asenath, the wife of Joseph, and Arsinoe, its Ptolemaic name. Those united depressions formed the Moeris of Herodotus.

The region might well be described, in the fifth century before our era, as a vast reservoir and back-water from the Nile, with a maximum level above low Nile at Memphis, fifty miles south-west of that city, about fifty fathoms deep, longer than its width, extending from north to south, surrounded by the Libyan desert, with an indented coast as long as the smooth sand-banks which form the Mediterranean shore of Egypt, blue, full of fish of twenty-two species, with flood-gates at the double mouth of the canal, whose embankments and clearance from silt annually cost $50,000 (£10,000), by which the engineers relieved Egypt from a dangerous flood, or stored up and distributed the water which entered or issued from the canal. A multitude of fishermen on its borders were engaged in catching and curing the fish which bred and multiplied in the lake, while the royalty on the fisheries averaged $250,000 (£50,000). Its waters escaped along the hill above Memphis. About the middle of the deepest part was an island. On it were two pyramids and a tomb. Against the structures were two figures, seated upon thrones. The height of the pyramids equalled the maximum depth of the lake.

The *Lacus Meridis* of the Ptolemaic maps—the Raiyān Moeris—is confined to the Raiyān depression, with an extension into the narrow valley of Muellah. The term Raiyān retains the name of the monarch honored by Islam, associated locally with the spring in the southernmost bay of the depression, and closely connected by derivation with the idea of irrigation. Moeris, of course, is, like the Latin word *mare*, or the English "mere," the exact equivalent of lake.

THE RAIYĀN PROJECT.

The whole subject of Egyptian irrigation has been treated with conspicuous thoroughness and ability by Mr. W. Willcocks, of the Indian Public Works Department, and one of the four Inspectors of Irrigation, who, under Col. Sir C. C. Scott-Moncrieff, Under-Secretary of State for Public Works, and Lieut.-Col. Ross, Inspector-General of Irrigation, succeed the Hyksos, Persian, Greek and French in foreign control of the native engineers. His book embodies the information collected during four and a half years of the irrigation systems of Egypt, and a *resumé* of the works carried out by Sir C. C. Scott-Moncrieff. The literature of irrigation, in general, is singularly scanty. Scarce a dozen titles can be found in the catalogue of any library. The volumes published by the State of California will soon be supplemented by those to be issued from the State Department in Washington. Mr. Willcocks provides a treatise which discusses systems of irrigation practised with eminent success for 4,000 years. It is curious to read how steel may now be introduced with advantage in the sluice-gates of canals for which the Sphinx was sculptured as warder.

One of its eleven chapters, one-twelfth of the entire contents of the book, is devoted to the Raiyān project. The whole volume is replete with information and will be found to be of the greatest value for all who are engaged in land reclamation schemes in countries where the rain-fall is insignificant. Extensive citations from this book have an obvious advantage. They are free from suspicion of exaggeration. They present prolonged and recondite researches reduced to logical sequence and

coherent form by a practical engineer, who contemplates that he may himself be intrusted with the execution of the works he recommends, and required to earn the interest which he promises on the capital which he estimates as sufficient. Mr. Willcocks appears to urge that summer irrigation impoverishes the land, and that basin irrigation, or an annual crop from flooded land is, in the long run, more productive. He has, however, explained that he objects to perennial irrigation when unaccompanied by those periodical floodings, in which the rich red waters of the Nile deposit the detritus of the Abyssinian mountains, mingled with the decaying vegetable matter transported by the White Nile from the swamps and marshes of Equatorial Africa.

Colonel Ross, in his admirable preface (p. xv.), shows the difficulty of draining Middle Egypt, especially the tract alongside of the Ibrahimiyah Canal, or, in other words, by the side of the railway between Beni-Suef and Assiūt. The Nile flood absolutely bars drainage into the Nile; the Raiyān basin offers the ultimate solution of this problem. In future years—he says—after the Wadi Raiyān canal has been opened, and the summer supply of the Delta assured, the money now spent in raising water to irrigate can be spent in draining the extensive northern swamps; the irrigation water being delivered free-flow.

It is simply incredible that strenuous efforts are continually made under the direction of the Great Powers, who represent civilized Europe, to destroy the navigation of the Nile. Artificial obstacles are placed across the canals, and all the mouths of the Nile barricaded as soon as a low stage of the water is reached. The

financiers, protected by British bayonets, force transportation out of its natural channels on to the railways, or delay it for twenty-four hours at a bridge, for the more convenient collection of tolls, whose character has been stated with entire frankness in the official utterances of Sir H. Drummond Wolff and Sir J. Fergusson. The benefits of the Raiyān scheme include improved internal water communication.

Colonel Ross gives an analysis of the chapter which treats of "the recently developed project of the Wadi Raiyān." "The storage of water in this sister depression to the Fayoum will remove many difficulties about summer supply. The principal difficulty is to get the capital, either by borrowing, or forming a company to furnish the water in exchange for some concessions. Considering that it now costs £60,000 ($300,000) to pump five million cubic metres (say 1,250 million gallons) of water into the Behera province, it does not seem a bad bargain to borrow a million and three-quarters ($8,750,000) to furnish twenty million cubic metres of water daily (*ca.* 8,000 cubic feet per second) and even more, *i. e.*, to pay £87,500 ($437,500) a year at five per cent. interest." As Colonel Ross points out, Egypt could borrow the necessary funds at five per cent. In other words the Raiyān project is considered by him an absolutely safe investment.

Two propositions were submitted to the British officials in Egypt.

First. Having placed unreservedly at their disposal all the information I had acquired, and having submitted to the fantastic, and, in my judgment, cruel and extortionate demands upon my life, health and private resources

in doing their work, in months spent in the desert with their engineers, or in putting my knowledge in a form in which it would influence the scientific, political and financial world and smooth their path, I offered to efface myself and leave them untrammelled in the execution of the work and the appropriation of the merit.

No remuneration of any kind, direct or indirect, was to be given me. It was to be considered sufficient if I were allowed to escape scot-free, without the *peine forte et dure*, which in Goethe's opinion, and my own experience, are still ready to invest with picturesque accidents the most judicious efforts to ameliorate the human lot or add to its intellectual wealth.

Second. When it was insisted that the gift to Egypt was incomplete unless the canal itself was finished without risk or cost to the bondholders or the taxpayers, and a net surplus paid into the Egyptian treasury, it seemed, again, that this was no function of mine, or necessary part of my work. The scientific examination of the Moeris problem required but a single visit to the untrodden summit of the Haram Medhūret el-Berhl, while any engineer could be invited and paid to spend thirty days in running lines of levels through the Haret el-Gehenna, whose name is well deserved. So also the Great Powers have furnished their ward with a financial staff, whose experience ranges from St. Petersburg to Calcutta. It was no business of mine to obtain the opinion of Lord Rothschild, the Council of Foreign Bondholders, the Imperial Ottoman Bank, or Sir J. Lubbock.

Two offers were nevertheless submitted. The first left to that bureau in the Department of Works specially created and charged with the expenditure of a mil-

lion of pounds, guaranteed by the Great Powers, all the engineering work. My confidence and that of the Egyptian Government in the skill and energy of Colonel Western and his staff was so complete, that there was little difficulty in obtaining authority from capitalists to provide the government with funds as the work advanced, secured upon the works themselves, with such participation in the benefits as might be determined. A scale was suggested.

The second offer simply accepted the estimates of the Egyptian Government and contracted to complete the work on their terms. We would agree to deliver the Raiyān Canal and flood-gates, according to specifications, for an annual payment not exceeding £50,000 ($250,000), purchasable for a lump sum of £1,000,000 ($5,000,000). The annual rent was in no case to exceed 70 per cent. of the net profits obtained by the government. These offers have not so much been rejected, as their final consideration postponed. They have been repeated and defined in the "Note on the Raiyān Project" submitted to the Department of Public Works in April, 1889. There is very little doubt, however, that the Egyptian Government, having expended another year in striving to find some other way of accomplishing the result, will borrow the money, guarantee the interest and itself do the work.

Considering its importance and the acknowledged benefits which will be immediately conferred upon Egypt, and, through the Valley of the Nile on the Equatorial Provinces, which have been transferred to the Mahdists, since the British occupation, as the result of the military and civil operations conducted by Hicks,

Gordon, Wolseley and Stanley, advised by Sir E. Baring, no personal interest should be allowed to intervene. What, in comparison with such results, is the naked assertion of the abstract right to bring to maturity a project, although the inception is admittedly the offspring of one's brain and heart, whose infancy required sedulous care, and the infant, destined to be a Hercules, was cradled in a shield and defended by the sword?

There are four possible channels by which the Raiyān Basin can be put in communication with the river. Two only are considered by Mr. Willcocks. The Abu-Hamed route involves a contoured canal in the desert along the southern edge of the Fayoum. It was regarded by Colonel Western as in all respects feasible at a moderate cost. Whether a shorter line, through the limestone hill, would, on the whole, be preferable is not, for the moment, essential. The former line fixes a maximum cost which can be used in working out the other elements of the project.

The only alternative scheme for the impounding of the surplus flood is that associated with the name of M. de la Motte. He proposes to build a dam across the Nile at Gebel Silsileh, 85 kilometres (50 miles) below Assūan (the first cataract) and make a reservoir in the desert plain of Kom Umbos. "This scheme is in a very embryo stage, and needs very much more working up to bring it to the complete and perfect state of the Wady Raiyān project, but it is roughly calculated to cost £4,000,000 ($20,000,000)" (p. 322.). Its great weakness lies in the dam 60 feet high founded on a not very homogeneous sandstone. Other objections include the detention and deposit of silt, with the consequent

raising of the bed of the reservoir, and annual diminution of its capacity.

The summary of the Raiyān Project, as given by Mr. Willcocks, is substantially in the following words; the parentheses are mine:

The cultivated area of Egypt is 4,955,000 acres, and the land capable of reclamation in Lower Egypt, (exclusive of over 1,000,000 acres contained in the areas now abandoned to the Mediterranean, and forming the brackish lakes bordering upon it, together with at least 500,000 acres elsewhere) is 1,260,000 acres. If one-third of the cultivated land and the whole of the land to be reclaimed were to be irrigated in summer, there would be required a summer supply of

$$\left(\frac{4,955,000}{3}\times 26\right)+\left(1,260,000\times 40\right)=93,000,000$$

cubic metres per day, of which the lands to be reclaimed would alone require 50,000,000 cubic metres per day. The mean summer discharge of the Nile is 42,000,000 cubic metres per day (16,800 c. f. per second) at Assūan, while there are years when it falls to 24,000,000 cubic metres per day, and hence the impossibility of doing any reclamation by summer cultivation on a large scale without storing water somewhere. The best known scheme before the public is that of Mr. Cope Whitehouse for storing water in a reservoir to the south-west of the Fayoum. This reservoir would be fed by a canal from the Nile in flood, and discharge back into the Nile in summer. The time during which the reservoir would be drawn upon would be from the 15th of April to the 25th of July, when the Nile is at its lowest. The elements of the problem, therefore, are the following:

First. A *basin* of sufficient magnitude to receive the Nile in flood; and of sufficient area to yield between the flood-surface of the intake, and the low-water mark of the outflow, all the additional water required during the hundred days of insufficient Nile.

Second. A *canal* capable of passing a certain quantity of water into the basin. If the section of this canal is only large enough to discharge the daily supply required from the basin, (when filled and used as a reservoir) it will take a considerable number of years to raise the water surface in the depression to the level of low Nile, as the bottom of the depression is over 200 feet below the level of cultivated land in the Nile valley, on the same parallel. If the canal is of large section, it would fill the reservoir in three years, and could be used as an escape in time of dangerous flood.

Third. The determination of the *water-surface levels* of the Nile, maximum, minimum and mean, during flood and summer, with the discharges corresponding to the different levels.

Fourth. The determination of the *minimum level of the Nile in flood*, below which it must not be allowed to fall. In other words, the quantity of water which could be delivered at the Raiyān Escape without prejudice to existing interests.

Fifth. The *Raiyān works to the west of the Nile Valley*, excavations, earth-works, pitching; and masonry works needed for regulation.

Sixth. The *works in the Nile Valley* needed for the passage of existing canals, drains, and the railway, by the large flood canal or escape.

Seventh. The *time* required to fill the reservoir: the quantity of water utilized after loss by evaporation and absorption has been eliminated.

Eighth. The *quality* of the water stored.

Ninth. The *effect* of reservoir water on the Nile water in summer in respect to the health of the towns depending for their water supply on the Nile.

Tenth. The *passage of the water* from the reservoir in summer through the existing canals in Lower Egypt, on the top of the ordinary summer supply, in order to reach the lands near the sea.

Eleventh. The *preparation of the lands to be reclaimed* so that the water may be utilized when it is obtainable.

Twelfth. The *cost*, capital required and means of earning interest on the capital.

"Granting the great advantages to be reaped from an increase to the summer irrigation of Egypt, and the necessity of this increase if the resources of the country are to be fully developed, there is no scheme more likely to attain this end than Mr. Cope Whitehouse's project for a reservoir in the Wadi Raiyān, South-west of the Fayoum. At no other place in Egypt can a reservoir be obtained without first building a dam across the Nile." Plate two gives a plan of the reservoir and the adjacent valley of the Nile, reproduced from Mr. Willcocks' work, without any modifications; which, nevertheless, especially in nomenclature, might have advantageously been made. "This plan was reduced from the (latest) original plan, prepared by a staff of engineers working under the orders of Colonel Western, Director-

General of Works. The Ministry of Public Works is examining the project in a very thorough manner; Colonel Ross, Inspector-General of Irrigation, examining the irrigation side of the question, and Colonel Western the constructive."

"Given the reservoir, the section of the canal, the water level in the Nile, and the other factors in the problem, it is a question of permutations and combinations as to which is the best method of carrying out the project. A small canal will cost little; but it will take many years to fill the lake, the interest charges will run up, and the water of the lake will possibly (?) become brackish. A large canal will cost much; but it will soon fill the lake, the interest charges will not mount up, and the water of the lake will possibly not be brackish. A large canal will also be of use in reducing appreciably the water level of the Nile during a very high flood. A very high flood comes seldom, but a breach of the Nile banks in flood is the greatest calamity which can overtake the country; and any scheme which promises relief to the country in flood deserves careful consideration."

With these preliminary remarks Mr. Willcocks proceeds to consider the twelve elements of the problem, as he conceives it, in detail. The parentheses here also contain explanatory remarks by the author of this paper.

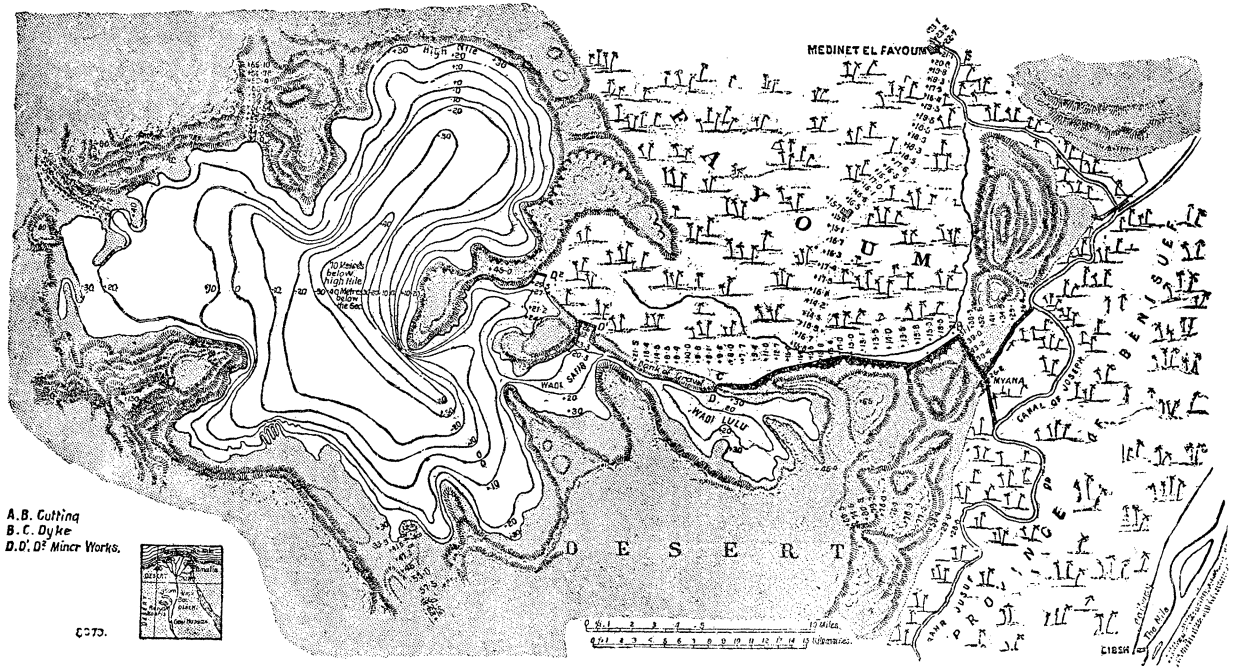
FIRST. *The size of the reservoir.* This is a fixed quantity. In Colonel Western's office, the large scale plan has been contoured and the areas covered by the different contours have been measured by a planimetre. The following table (abridged) contains this information.

AREA AND CUBIC CONTENTS OF THE RAIYĀN RESERVOIR.

R. L. of Contour.	Area in Square Metres.	Area in Egyptian Acres.	Contents of Reservoir in Cubic Metres, below the Contour.
30	686,600,000	163,475	20,559,640,000
25	618,300,000	147,214	17,297,390,000
20	550,000,000	130,952	14,376,640,000
10	397,904,000	94,739	9,637,120,000
Sea level.	301,100,000	71,690	6,142,100,000
—10	231,800,000	55,190	3,477,600,000
—20	163,075,000	38,127	1,503,225,000
—30	55,562,500	13,229	410,037,500
—40	22,037,500	5,247	22,037,500

The maximum flood level of the Nile at the (proposed) take-off of the reservoir canal is Reduced Level + 31.8 metres (about 100 feet above the Mediterranean), the ordinary high flood level is R. L. + 30.3, the low flood level is 29.0 metres, and the summer level is about 22.0 metres above mean sea. These levels are referred to the Barrage zero, or mean Red Sea, .60 metre above mean Mediterranean Sea.

Colonel Western thus describes the Wadi Raiyān: "This valley, a depression in the Libyan Desert, discovered by Mr. Cope Whitehouse in 1886 (this date being taken as the first official communication to the Department of Works of a survey verified by lines of levels, as distinguished from aneroid observations), lies immediately to the south-west of the Fayoum province, but separated from it by a range of low hills, averaging some 6 kilometres ($3^1/_3$ miles) in width, and with heights of about 60 metres (196 feet) above sea level. Two passes, however, leading from the Garak (the Rharaq of Schweinfurth, the Gharaq of the author's maps) basin of the Fayoum, with levels of about + 26 metres, have been found in this dividing range, and, except for these two passes or entrances, the Wady is everywhere



The Raiyān Basin, drawn by Cope Whitehouse, 1888.

bounded by hills of at least + 36 metres above mean sea."

"The soil of the Wady is for the most part composed of desert sand and pebbles, overlying in places a yellow clay, but this desert sand is for about one-sixth of the area hidden by drifted sand-hills, or ridges rising some 5 to 10 metres above the general plain. Towards the north of the Wady, there are two fresh water springs (but no inhabitants) and near there, a few date trees and some brushwood grow. The deepest level of the Wady Raiyān reaches 40 metres below sea level (about 220 feet below high Nile). To the south of the Wady and connected with it at a level of + 55 metres is the Wady Muellah, a valley about 1½ kilometres width and seven length. Its lowest depression is + 25 metres (about 35 feet below mean high Nile near Behnesa, opposite its southern extremity). In the Wady Muellah there are ruins of ancient buildings (with fragments of a Greco-Roman period, further identifying the spot as the Dionysias of the Ptolemaïc text and map). There is a fair amount of coarse vegetation near them."

"Two other small depressions have been found, connected with the Wady Raiyān at its north-eastern extremity at a contour lower than the level of the flood Nile. They lie to the south of the Gharaq basin of the Fayoum province and are separated from it by a ridge with a level of + 35 metres, one kilometre in width. The easterly depression (the Wadi Lulu, or Valley of the Pearl, a modern name given to it by the author of this paper) is about 10 kilometres in length by 4 kilometres mean width and has a bottom at about + 15 metres."

SECOND. *The Reservoir Canal.* "Referring to the

plan," says Mr. Willcocks, "it will be seen that Biba is the point chosen for the take-off of the canal from the Nile. It is 163 kilometres above the Barrage along the deep channel of the Nile (85 miles south of Cairo by rail). Of course any other point near it may be chosen, but considering the lie of the basins and their feeders, it will be difficult to choose a better place. On the plan there are two lines given for the canal; one is called the 'Proposed Reservoir Canal' and has been (repeatedly) levelled and surveyed, (examined by Colonel Western in person, and pits sunk to test the character of the material to be excavated). The other is called the 'Alternative line.' All calculations have been made on the former. If the surveyors can find a fairly good line along the latter, it will be decidedly the better line, as it makes straight for the reservoir and avoids the banking up in the Fayoum Valley necessary on the former line."

Neither line presents the smallest engineering difficulty, or would be above the capacity of a native provincial chief-engineer. The direct line involves a tunnel about five miles in length through horizontal limestone. With a bed width of 80 metres, and a height of 10 metres, it would be more convenient to drift a series of openings. Undoubtedly this would be the channel selected if the Irrigation Department was directed, as in the days of Raiyān ibn el-Walīd, the Hyksos monarch, who, according to Semitic tradition, proposed to Jūsuf ibn-Jacoub the problem of regulating the Nile, or when Ipsambūl and the Sphinx were carved in the living rock, and the hills opposite Memphis emptied of incalculable masses of stone.

The splendid effect of the façade with the stream, 250 feet in width, gushing clear and blue from the white portal, between colossi carved with the least expenditure of labor, but the most ingenious adaptation of natural conditions in the stratified rock, would not now have the slightest weight with the Department of Public Works and their financial masters. The passage itself, its forest of columns, the Cathedrál-Mosque of Cordova extending miles in length, the vast air shafts, 200 feet in height, corbelled out in mouldings decorated with sentences from the Qurán, telling in words that history of Jūsuf written in water, fruits, flowers, fields and houses, temples and mosques along the River of Joseph and in 'the land of a thousand days' will not be attempted. Such considerations are absolutely alien to the actual administration as controlled by foreign influences.

It would be otherwise if the Viceroy, whose devotion to art and science has been tangibly exhibited, were free to apply the surplus of enlarged revenues according to his better judgment.

"The (total) length of the proposed canal is 46 kilometres (27 miles) from Biba to the point A, in the reservoir. The length of the alternative line is about 30 kilometres (18 miles). The slope of the canal will be $\frac{1}{20000}$, the ordinary canal slope in Egypt. This slope, with a hydraulic mean depth of between six and seven metres (20 feet) will give a mean velocity of about one metre per second (2½ miles an hour), a velocity which allows neither silt deposit nor scour in the Nile Valley."

THIRD. *Flood and Summer Levels of the Nile at*

Biba. As a rule there is such a heavy demand for water during the month of August, that in any but a very exceptional year no water (in Mr. Willcocks' opinion) can be taken from the river, and this month must be left out of the calculations.

DISCHARGE OF THE NILE AT CAIRO.

Month.	Mean discharge in cubic metres per 24 hours.	Feet per second.
January	151,000,000	60,400
February	110,000,000	44,000
March	70,000,000	28,000
April	45,000,000	18,000
May	34,000,000	13,600
June	34,000,000	13,000
July	70,000,000	28,000
August	525,000,000	210,000
September	675,000,000	270,000
October	675,000,000	270,000
November	400,000,000	160,000
December	260,000,000	104,000

The maximum flood of 1874 discharged 1.032 million cubic metres in a single day; the minimum flood of 1877 discharged 465 million cubic metres, or less than one-half that amount.

Mr. Willcocks puts the entire discharge of the Nile during the year at 93,000 million cubic metres. If 3,000 million cubic metres are required for the basins of Upper Egypt, and 50 million c. m. were furnished for daily consumption there could never be a year in which 50,000 million c. m., or double the contents of the Raiyān Reservoir, would not pass into the Mediterranean without contributing in the least degree to the fertility of Egypt. The regulation of the Nile at the Barrage in July and part of August would put a certain volume of

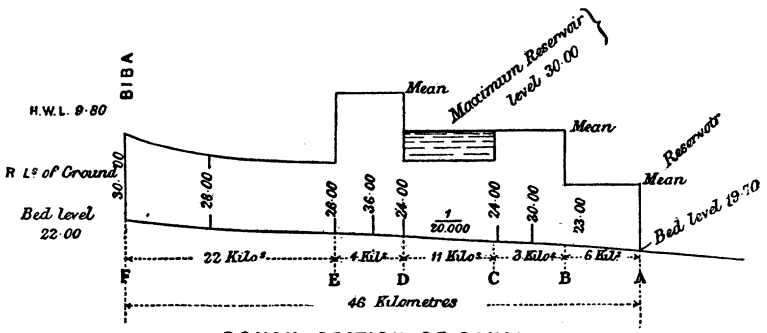
water at the disposal of the government for the Raiyān basin. The summer, or low Nile, level at Biba may be taken as 22.00 metres.

FOURTH. *Levels at which the Nile must be maintained for flood irrigation.* In September a gauge of 16.3 should be generally maintained at the Barrage, though alternate week gauges of 16.3 metres and 15.8 metres (above zero) would suffice for the irrigation until the 10th October. From the 10th to the 20th October, a gauge of 17.0 metres is needed at the Barrage to allow all the high lands to be irrigated for the winter crop. After the 20th October, the canal might take as much as it liked from the Nile, or from the basins above it, except in extraordinarily low years like 1888.

In an average year, from the 1st of September there is available a discharge of 57,500,000 cubic metres per day, increasing to over 100,000,000 on the 15th September. Between the 10th and 20th October, no supply is available, as the Nile berms have to be irrigated, while after the 20th October, the canal can take as much as it can carry. It is better (in Mr. Willcocks' opinion), to depend on an alternate week supply in low years than on any regulation at the Barrage, because the former meets the requirements of Upper Egypt, north of the canal, as well as those of Lower Egypt, while the latter meet the requirements of Lower Egypt alone. A fluctuating supply in the Nile in a high year like 1887, would bring down the Nile banks, but in high years this alternate weekly supply will not be necessary. In the low Nile years, when it is necessary, no harm will be done by a difference of half a metre, which this system of filling will entail.

As far as a high Nile flood is concerned, a canal incapable of carrying 100 million cubic metres per day at the high flood gauges, would be of little use. A difference of 50 centimetres at the Barrage gauge when the readings are between 18 and 19 metres means a daily discharge of that amount. Taking high flood relief as the most important factor in the calculation (of the size of the proposed canal) and the level of the bed of the canal at 22 metres at the take-off, the canal should discharge 100 million c. m. per day with a depth of water of 9.8 metres. A canal with a bed width of 80 metres (250 feet) and side slopes of ½ will accomplish this result.

The following is a rough longitudinal section of the proposed canal.



ROUGH SECTION OF CANAL.

LONGITUDINAL SECTION OF CANAL.

The earthwork estimate is as follows:

From F to E: Length, 22,000 metres; mean depth, 6.5 metres. Contents, 12,370,000 cubic metres. This is capable of reduction by following the Bahr Jūsuf in places.

E to D.—Length, 4,000 metres; mean depth, 15 metres. This section is a soft limestone cutting (to the depth of about a metre, resting upon a very compact clay, impregnated with salt, and dissolving with extreme facility into fine mud), and here the bed may be lowered 4 metres, as recommended by Colonel Western, and the depth of water becomes 13.3 metres. The bed width here may be reduced to

40 metres, which will give such a slight afflux that it will not be felt within 10 kilometres of the head. The material to be removed is 4,484,000 cubic metres.

D to C.—Length, 11 kilometres. The hill (along the southern edge of the Gharaq basin of the Fayoum slopes gently from + 60 m. to + 14 m.), and the canal can follow any contour decided upon (and the required section thus obtained either by a deeper excavation or a higher bank on the lower side—the only one required—as may be considered expedient and economical). If a contour of + 24 metres is chosen (and the bank given a top width of 15 metres), a sectional area for the embankment of 200 square metres will cover all contingencies. The breadth of section, (varying with the irregular edge of the desert, and reaching in some places a width of 1,500 metres, or over a mile), will make up for any loss in depth: material to be handled; 2,200,000 cubic metres.

"C to B.—Length, 3 kilometres, depth, 14 metres, and (bed) width, 40 metres, since this is in part another soft limestone ridge (with pebbles, desert sand and clay): material; 2,352,000 cubic metres.

"B to A.—Length, 6,000 metres, depth, 3 metres: 1,500,000 cubic metres.

The estimated cost of work is:

Section F to E.—	12,370,000	cubic metres at	£.04 (20c.)=	£494,800	=($2,474,000).
" E to D.—	4,484,000	" "	" .10 (50c.)=	448,400	=($2,242,000).
" D to C.—	2,200,000	" "	" .04 (20c.)=	88,000	=($440,000).
" C to B.—	2,352,000	" "	" .10 (50c.)=	235,200	=($1,176,000).
" B to A.—	1,500,000	" "	" .04 (20c.)=	60.000	=($300,000).
Total....	22,906,000	" "	"£.58 (29c.)=	£1,326,400	=($6,632,000).

FIFTH and SIXTH. *Masonry Works.* The masonry works are needed for regulation, and for the accommodation of existing works.

1. *The Bahr Jūsuf Crossing and Reservoir Regulator.* This can be built on the limestone rock with a 40 metre wide platform, and a 2.5 metre depth of masonry, the levels of the canals will allow of a level crossing.

40 openings...	at £1,500 =	£60,000 =	$300,000
Wing walls.....		10,000 =	$50,000
2,000 square metres regulating gates.....	at £9. =	18,000 =	$90,000
Total.....		£88,000 =	$440,000

2. *The Sugar Railway* will be diverted to the government railway bridge at a cost of £20,000 ($100,000).

3. *The Ibrahimia Canal* will be syphoned under the reservoir canal. The discharge to be passed is 3,000,000 cubic metres per day, and allowing a head and velocity of 2 metres per second, 8 pipes of 1.5 metres diameter will take the water across.

Estimate 8 pipes.....at £3,000 = £24,000 ($120,000), 300 tons + masonry.

4. *The Government Railway.* 4 feet 8½ inch gauge, 80 metres wide canal. Tons of iron, 1,500 at £25.; £37,000 ($185,000). With the work can be combined the regulating head of the reservoir canal, eighteen openings of 5 metres at £2,500 ($12,500)=£45,000 ($225,000).

Railway Bridge.....	£37,500	($187,500)
Regulator.....	£45,000	($225,000)
Total	£82,500	($412,500)

The masonry works therefore, will amount to

Bahr Jūsuf Crossing and Regulator.....	£ 88,000	($440,000)
Sugar Railway Diversion.....	20,000	($100,000)
Ibrahamia Canal Syphon.....	24,000	($120,000)
Head Regulator and Railway Bridge...	82,500	($412,500)
Total	£214,500	($1,072,500)

The whole of the earthwork and masonry works will therefore (according to Mr. Willcocks) amount to

Earthwork.....	£ 1,326,500	($6,632,500)
Masonry.....	214,500	($1,072,500)
Land, 1,600 acres at £30 ($150.).....	48,000	($ 240,000)
Total	£1,589,000	($7,945,000)

It will be a matter of interest to all those concerned in irrigation works to study these estimates, but no American engineer would, for a moment, admit that they furnish a basis upon which contracts could be let to the advantage of the government. The difference

between the method of constructing American and Indian railways is exhibited in the excessive allowances for work which could never be required.

Mr. Willcocks is not only an engineer of great ability and indefatigable energy, but deservedly enjoys the reputation of a readiness to adapt his plans to circumstances, in a manner characteristic rather of the United States than of Great Britain. His field work would be very different from his plans on paper. Availing himself of the tremendous velocity obtainable through the Lulu and Safir basins and the rapid slope of over 150 feet into the Raiyān depression much of the excavation would be accomplished by natural forces.

The Raiyān Works proper commence at the Bahr Jūsuf, and the western (desert) edge of the Nile Valley. Former estimates of £500,000 ($2,500,000) would not be exceeded. The great canal across the Nile Valley from Biba would in reality be a broad shallow basin cultivable once a year throughout its entire area. The masonry works may be taken as reasonable, but a part of the money would be otherwise expended. The total cost, therefore, of the Raiyān Project should be estimated thus:

Raiyān Canal of Escape, and Supply	$2,500,000
Works in the Nile Valley	1,500,000
Total, (£800,000)	$4,000,000

SEVENTH. *Quantity of Water capable of being utilized (without pumping). Time of filling Reservoir.* It appears (from Mr. Willcocks' tables) that for forty days each flood a depth of water of 8 metres (25 feet) may be taken into the canal, for twenty days the basins above the canal may be discharged into the canal

through the Bahr Jūsuf, for the thirty days of November a depth of 6 metres of water may be counted on, for December a mean depth of 4.5 metres, for January a depth of 3.0 metres, and for February of 2 metres. With an 80-metre wide canal, slope $\frac{1}{20,000}$, the (daily) discharges are:

8.0 metres depth	67,000,000
6.0 " "	42,000,000
4.5 " "	25,000,000
3.0 " "	13.000,000
2.0 " "	6,000,000

Therefore the supply obtained per annum would be:

September and October	60×67,000,000=4,020,000,000	cubic metres.
November	30×42,000,000=1,260,000,000	" "
December	30×25,000,000= 750,000,000	" "
January	30×13,000,000= 390,000,000	" "
February	30× 6,000,000= 180,000,000	" "
March, from Bahr Jūsuf	30× 5,000,000= 150,000,000	" "
Per annum,	6,750,000,000	" "

Referring to the table of contents of the Raiyān depression, and allowing for evaporation and absorption, it appears that:

	Metres above sea.	Contents cubic metres.
At the end of the first year the water in the lake would rise to	+ 2=	6,750,000,000
" " second " " " "	+17=	12,892,100,000
" " third " " " "	+27=	18,566,760,000

In other words, the lake would be filled to the level +27 metres (above sea), or about 5 metres (16 feet) above low Nile at the end of the third year. It could give a half supply that year. The fourth year the lake would be in full working order and could be filled to +28 metres. Allowing 1 metre as loss by evaporation from April 1st to July 31st (an excessive estimate), the water in the reservoir could be utilized (without pump-

ing, either to fill or empty,) to the depth of 2 metres, *i. e.*, a stratum of water of 1,263,920,000 cubic metres, or a discharge of 12,639,200 c.m. per day (about 3,000 million gallons for 100 days.) This amount would flow back into the (Nile) canal through the reservoir canal as levels would suit. There are years when the lake could be filled to R. L. 29.0 or R. L. 30.0, but above R. L. +28 could not ordinarily be counted on.

It is obvious that Mr. Willcocks does not mean to limit the available portion of the 20,000 million cubic metres stored in the Raiyān Reservoir to little more than one-tenth. The water is to be consumed at all levels above the Mediterranean on its way to Alexandria, Port Said or Suez, and even slightly below the level of the sea on the bed of Lake Abūkir. A straight, clear channel past the pyramids, connecting with the Alexandrian canals, would lower the lake another 5 metres without artificial means.

EIGHTH AND NINTH. *The Quality of the Water, and its effect on the summer water of the Nile.* Mr. Willcocks quotes at length from the report of a meeting of the Khedivial Geographical Society, March 16th, 1888, in which this and kindred points were fully discussed.

Pierre Bey, engineer-in-chief of the *Compagnie des Eaux du Caire*, inquired whether there was any danger of infiltration into the Fayoum. M. Lieurnur, engineer-in-chief of the expedition of 1888, responded, and pointed out that it was definitely settled that the two depressions are everywhere separated by broad and solid strata of rock, except at two narrow passes of inconsiderable width, and little below the level of high Nile. In answer to a second question, whether the lake

might lose a part of its contents by infiltration towards the Mediterranean, he said that as the Raiyān and Fayoum basins, although 40 metres below the sea, have no infiltration into them, such a risk could not be considered as within the range of possibility.

It may be added that the silt-charged waters of the Nile speedily fill interstices and thus canals and embankments puddle themselves.

Salem Pasha (the largest landed proprietor in the Gharaq district) desired to know whether the water might not be impregnated with salt. Mr. Cope Whitehouse replied that this subject had been attentively considered, and that the unanimous conclusion of the officials in the Irrigation Department, as well as the native chief-engineers, whom he had taken pains to consult, was in the negative. There is salt in the Raiyān basin as everywhere else in Egypt, on the tops of its hills and in the soil of its fields. A shallow lake would be brackish. The Birket el-Qerūn when low is quite brackish. It contains all the salt which has passed into the Fayoum for countless ages, from a pre-historic period, concentrated from a surface of 1,250 square miles into a comparatively small area with a depth of only 8 metres (25 feet). Whenever this lake has attained a greater depth the upper stratum has become quite fresh, as evidenced by the remains of shell-fish. Even now the upper stratum can be used to drink; he had often so used it for several days at a time. The bed of the Raiyān basin contains in certain places small saline deposits. The pools formed in the lowest parts would be brackish until they had attained a certain depth. When the lake had been filled to a depth of,

say, 20 metres, the water would be quite fresh. The large quantity added and withdrawn each year would also tend to change the whole volume, while any percentage of salt absorbed would be infinitesimal, and of no possible importance in relation to either agriculture or its use in drinking.

Dr. Schweinfurth was inclined to think that the Raiyān depression could be more advantageously treated like the Fayoum, and used as an additional cultivated area. He repeated the fear that the water might become salt.

Mr. Cope Whitehouse said, in reply, that the difference between 80,000 (Egyptian) acres, cultivated once a year, and (not less than) 2,300,000 acres of *sefi* (summer) cultivation was in itself a reason why the reservoir scheme must be considered preferable, if feasible. In any event there is no risk incurred. Long before any part of the water which had been poured into the Raiyān basin could be discharged again into the Nile, the problem would have received a practical and final solution. If the water proved unfit for use, the canal would nevertheless have paid for itself as a flood escape, and as an irrigation canal for the Raiyān district. He might also say that if the Raiyān basin was the Lake Moeris of the Ptolemaïc maps, we have the experience of 2,000 years to put against a conjectured possibility. He would, however, ask the Inspector-General of Irrigation for his opinion.

Major (now Lieut.-Colonel) Ross—who was received with warm applause—said that he entertained no apprehensions in regard to the purity of the waters and explained his reasons at length.

He wished to add in respect to the amount of land

which could be cultivated by this reservoir that Mr. Cope Whitehouse had confined himself to the Delta. If twenty million cubic metres of water, per diem, could be added to the summer supply, it would enable the Department of Public Works to increase the amount now allotted to the cultivation of Upper Egypt. There is also a large area in the plain near Kom Ombos, which, by the scheme recommended by Mr. de la Motte, would be converted into a storage reservoir. It is excellent land and can be easily irrigated. *Sefi* cultivation might be largely extended in the provinces of Minieh and Beni-Suef. Cultivation in the Fayoum could also be increased. The Government would not be obliged to economize its water supply in Upper Egypt, because the Delta would obtain a part of its normal, as well as an additional, supply from the Raiyān reservoir. Another ten million cubic metres of daily supply would also go far to put a stop to corruption in the Delta. The strain upon the honesty of the local officials, when offered a bribe for a few hours' more water, is very great, and sometimes irresistible.

Mr. Lieurnur confirmed what had been said by Major Ross in regard to salt. In accordance with his instructions he had sunk experimental wells all over the basin, and had not found salt except in insignificant quantity. The bottom of the basin is rock, covered with clay and drifted sand hills.

On this point it may be added that it is much to be regretted that Dr. Schweinfurth should have given expression to a doubt on this subject. The question was subsequently examined by Osman Bey Ghalib and Dr. Seckenberger, and they agree with Colonel Ross

and all other experts. No project has probably ever met with such universal favor as this Raiyān scheme. Thousands of engineers, American, Egyptian, English, French and German have had an opportunity of studying it. The most eminent men have urged its immediate execution. Objections of a somewhat similar character, transmitted through Sir E. Baring—British Agent and Consul-General—to the Foreign Office, have contributed materially to delay the actual completion of the work. "The purpose of the government," says Herodotus, "in constructing this reservoir was to supply (good) Nile water to the inhabitants of the towns not lying upon the (main branches of) the river; for previously they had been obliged after the subsidence of the flood (as at present) to drink a brackish water which they obtained from the wells."

TENTH. *Passage of the Raiyān Water Through the Canals of Lower Egypt.* The canals taking off from above the Barrage will be capable of utilizing the following discharges at R. L. 14 metres on the Barrage, which is the maximum gauge to which water is to be held up in summer:

	Cubic metres.
Behêra	8,000,000 per day
Menoufieh and Gharbieh	16,000,000 " "
Dakalia, Sharkia and Kalubia	20,000,000
Total	44,000,000

Since the *mean* summer discharge of the Nile at Cairo is 34,000,000 cubic metres per day, and the reservoir can supply at least 12,000,000 per day in summer, the existing canals will (to that extent) suffice.

ELEVENTH. *The Lands to be Reclaimed near the Sea* will have to be provided with canals and drains. An

expenditure of £2 ($10.00) per acre on the land to be reclaimed must be considered in all estimates of cost of reclamation, in addition to the water supply in summer. The winter supply will have to be provided against also in some of the provinces.

TWELFTH. *Cost of the Project and Time Required.* Mr. Willcocks estimates the cost at £1,589,000, *if everything has to be done thoroughly.* The canal will, he thinks, take three years to complete if machinery is freely employed; and the reservoir will take three years to fill.

Prime cost.....	£1,589,000	($7,945,000)
Interest at 5 per cent. for six years....	476,000	($2,380,000)
Total cost, including interest.....	£2,065,000	($10,328,000)

How can interest be calculated on the entire total cost for the three years in which the works are in progress? The interest the *first* year would not be £10,000, and the ordinary deferred payments to the contractors would still further effect material reduction.

The Manchester Ship-Canal has established a rate of excavation and earthwork which would enable a contractor of equal energy to open the canal of escape in a single year. It would immediately begin to earn the amount agreed upon as remuneration for this part of its duty. The small basin, the Lulu Reservoir, would be also available for storage, and a crop grown on the plateaux of the Raiyān depression wherever water lodged for over ten days.

The masonry works would not be required until the third year after the escape canal had been completed, and it would be inexpedient to undertake them until after the escape had been worked. Official estimates

are influenced by precisely the opposite calculations to those which induce the capitalist to add fifty per cent. to the figures of an ordinary project. The British Government desires to increase the Egyptian debt, without guaranteeing either principal or interest. It has been proposed to use the Raiyān project to influence the Great Powers. The liberty to borrow a large sum would be convenient. If the works were executed for half the estimates there would be so much more to the credit of the Irrigation Department.

Mr. Willcocks concedes that, by carefully selecting the site of the canal, and economizing in the hill slopes, the total cost (of the completed works) might be reduced to £1,800,000 ($9,000,000). The annual interest charge would then be, at five per cent., £90,000 per annum. Nothing is said about maintenance charges, probably because he considers them too insignificant.

This undertaking appears (to him) so vast, and the difficulty of insuring a return so great that no private company, except a guaranteed one, could undertake it. "As far as Egypt is concerned, however," he says, "the completion of this reservoir would permit of a *new province being formed in the north of Egypt*, and give an impetus to the reclamation of the waste land which would in the end have a marked effect on the revenues of the country. With flush irrigation in summer assured land could easily pay ten shillings ($2.50) per acre. With a canal of eighty metres in width a discharge of 12,000,000 cubic metres per day in summer can be guaranteed for £1,800,000 ($9,000,000). The interest on £1,800,000 at five per cent. per annum is £90,000, ($450,000) or £75 ($375) per million cubic metres

(400 feet a second). Twelve million cubic metres per day would suffice for 300,000 acres of rice, or 400,000 acres of rice and cotton combined. To reclaim 400,000 acres, it would be necessary to spend £2 ($10) per acre, or a capital of £800,000 ($4,000,000). A company, therefore, which received the concession of the Raiyān reservoir and 400,000 acres of land in the Birrīya (uncultivated Delta) would need a capital of £2,600,000 ($13,000,000). If the undertaking were successful a net profit of fifteen per cent. might be obtained, but the company would always be at the mercy of the Government."

It seemed better to give the summary of the projected restoration of the Raiyān Moeris (as far as possible) in the words of Mr. Willcocks. Everything that he concedes in its favor is clearly to be accepted as the official admission of men of marked ability, enjoying every opportunity of arriving at correct results. In the opinion of the Hon. John Cardwell, late Consul-General of the United States, himself a warm sympathizer in my efforts, the project was reluctantly examined with the expectation and hope that it might easily be exposed as a delusion.

No capitalists, of course, would raise the money in the form contemplated by Mr. Willcocks. The money required for canals and drains in the Delta could be obtained from local enterprise. No guaranty would be required from the Government except an undertaking to allow water to flow in and out of the canal, at certain stages of the river, and to pay, at a fixed rate per million cubic metres, for the benefits thus conferred.

Sir C. C. Scott-Moncrieff is in this dilemma. If he

advises the Egyptian Government to solicit from the Great Powers the right to increase the indebtedness of Egypt, he pledges his position and reputation to the absolute certainty of the enterprise. He knows that every penny wrung from the peasant is a hardship, and that the power of Egypt to borrow at between four and five per cent. would be seriously strained by the unprofitable use of any such sum of money as £2,000,000. Taking only the absurdly small estimate of £6,000,000 ($30,000,000) as the total cash value of the Raiyān Reservoir, Mr. Willcocks estimates my gift to Egypt at £4,000,000 ($20,000,000); the actual value, of course, with skillful management, would approach £100,000,000 ($500,000,000).

If, on the other hand, there is any risk, what is it? What is its value in terms of enhanced interest or prospective profits offered to the capitalist? Let Sir C. C. Scott-Moncrieff draw up the terms of a concession, or modify those already submitted. They embraced the alternative of lending the Government the necessary funds, without a guaranty, on participation in net earnings, or of completing the works in one-half the time, and at one-half the cost on which Mr. Willcocks would earn fifteen per cent. and Sir C. C. Scott-Moncrieff concedes ten per cent. It may be observed that no allowance is ever made for any remuneration to the discoverer, inventor, or advocate of the Raiyān project.

Vastness is no attribute of the engineering works detailed by Mr. Willcocks. The original scheme, including the conversion of the Fayoum into a fertile province, with its borders and approaches crowned with pyramids and a pyramid-hill where it was deepest, a canal—a river,

not a stagnant ditch—from Assiūt to Alexandria, fit channel for Indo-Mediterranean commerce, passing at the foot of Memphis, a throne of empire, was vast in every sense of the term. Some elements of the sublime might be thought to attach to the pursuit of the True, the Beautiful, and the Good—the defense of the dead from aspersion, and of the living from pestilence and famine. The removal of some millions of baskets of earth is literally child's work.

"In spite of much ridicule and some opposition," writes Mr. Moberly Bell, "Mr. Cope Whitehouse has held to his project with all the tenacity of an enthusiast and has now the well-earned reward of seeing his scheme regarded as practicable and profitable by men whose judgments cannot lie under the suspicion of being influenced by the poetical enthusiasm of the student who originated them. It is probable that if he had appeared in Egypt as the mercenary would-be promoter of a simple commercial enterprise his views would from the first have received more serious consideration. It is, however, at least equally probable that they would not have achieved the same success. He may now be fairly congratulated on having proved the practicability of a scheme which was by many regarded as the dream of the visionary enthusiast."

Sir Edgar Vincent, as Financial Adviser to the Khedive, in his memorandum on the subject (1888) said: "If, after the Barrage has been working for three or four years, it is found that an increased supply of water is required and can be dealt with, the scheme of Mr. Cope Whitehouse will become a valuable instrument for the agricultural development of Egypt. If it were possible to

make the scheme entirely self-supporting by granting Mr. Cope Whitehouse, for a term of years, certain barren lands which his reservoir would render cultivable, such a proposal would have my hearty support." He added with generous courtesy: "I cannot conclude this memorandum without expressing my high sense of the intelligence and perseverance with which Mr. Cope Whitehouse has pursued the realization of his object."

Sir Julian Pauncefote, as permanent Under-Secretary of State for Foreign Affairs, on January 12th, 1889, wrote: "With reference to my letter of the 13th of August last, and to previous correspondence respecting your scheme for the creation of a large reservoir in the Raiyān basin for the storage of Nile water for irrigation purposes, I am directed by the Marquis of Salisbury to inform you that Her Majesty's Agent and Consul-General at Cairo (Sir Evelyn Baring) has received a note from the Egyptian Minister for Foreign Affairs (Zulfikar Pasha) stating that the project has been carefully examined by the Egyptian Government, but that after full consideration they have come to the conclusion that they cannot adopt your proposals, while the benefits which might accrue from their adoption are fully acknowledged. I am to add that Her Majesty's Agent and Consul-General, while regretting that Egypt is not able to profit by the execution of the project which you have prepared with so much care and skill, states that he has satisfied himself that the project has been considered with the greatest care and attention by Sir C. C. Scott-Moncrieff and Colonel Ross, who, as you are aware, are the responsible advisers of the Khedivial Government in such matters."

The Raiyān project, then, is in "a complete and perfect state" (Willcocks, p. 322). The Khedive, as befits the ruler of Egypt, displays that disposition to further its execution, which his judgment, tact and practical acquaintance with the needs of his people approve. The native officials and the inhabitants co-operate. The British Government assumes all the responsibility for the delay, basing the attitude on the recommendations of its representative. Sir Evelyn Baring has authorized me to make public his personal recognition of the value of the work, and expression of regret that circumstances should not permit it to proceed as rapidly as seems to me desirable.

Lord Salisbury has given the subject some attention, but whether from recondite motives of profound policy, or influenced by the qualified, and in some respects erroneous, information laid before him, this most able of Foreign Secretaries has not allowed his hand to close upon the powerful weapon which has for some time been well within his reach.

Mr. Gladstone, with his keen love of Hellenic literature, has thrice sought occasion to offer words of encouragement and commendation. On both sides of the House of Commons, but especially from the Liberal side, assurances have been given that this question would never be treated as political.

The King of the Belgians early manifested a personal interest, expressed in terms which were flattering in the extreme.

The French Government, also, I am credibly informed, would further the project as tending to improve the state of Egypt, without regard to purely political considerations.

If, as Sir Samuel Baker points out in the *Fortnightly Review*, October, 1889, every river tributary to the Nile should be controlled by weirs, or dams of masonry, "the scheme for the restoration of Lake Moeris (in the Raiyān depression) as the great reservoir of the Nile, proposed by Mr. Cope Whitehouse for the security of Lower Egypt, would be accomplished as a natural result of engineering science, which had bridled the untrained jaws of Egypt's river, and guided its course to the service of mankind." A true Fountain of the Sun, it would bring Light and Life to the heart of Africa. It would once more challenge the admiration and esteem of the world for those who thought that by such great works they reared an imperishable memorial to attest the splendor of noble purpose when applied to guide and restrain the capricious hand of Nature for the health and wealth of the distressed inhabitants of the Valley of the Nile.

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